Introduction

By Cherub Log

Most of the Radar articles appearing here have been contributed by those ex RAN personnel who were closely involved in the development, manufacture, repair and use of the then highly secret technology during the years of WW2 and immediately after. In recalling events which had occurred up to 65 years prior, it is reasonable to expect aberrations occasionally by some of the authors.

The concept of Radar had been enunciated by the German physicist Heinrich Hertz in 1888, and was later demonstrated in Germany in the early 1900s. However, nothing was done then to develop the concept, because the technology to do so did not exist. During the 1920s and 1930s the use of wireless telegraphy and wireless telephony grew dramatically, largely due to the invention and use of the thermionic valve and its derivatives. This technology was the basis for Radar to come to reality. Impending European hostilities during the 1930s added emphasis to development of the concept into a workable device which could provide a decided military advantage. By the mid 1930s, Radar was at last becoming a reality. So whereas Radar's gestation was some 50 years, comparing its difficult birth with the mature product we now see after a further 50 years of development, it was then quite Stone Age.

Although various experimental models of Radar sets had been produced since mid 1935, possibly the first successful system was the UK developed Chain Home Radio Location which commenced secret operations in July 1937. Successful trials subsequently led to the establishment of 20 RDF stations across southern England. Because of the limitations of vacuum tube technology, the Chain Home Radar operated at a frequency of 25 MHz, a wavelength of 12 metres. It was only a few years later that the British invented the cavity magnetron resonator which could produce high power pulses at a frequency of 10,000 MHz, a wavelength of 3 centimetres. This device, when used as the transmitter in conjunction with the US developed klystron local oscillator, was a quantum leap forward in Radar technology, and placed the Allied military far ahead of its Axis opponents in the science of Radar assisted weaponry. A pulsed wavelength of 3 centimetres gave a far more accurate definition of range and bearing of a target than that of a longer wavelength pulse.

In reading the articles which follow, this point of the primitive state of the art should be kept in mind. There was no Google to list thousands of references for the design teams to use. The computer was a futuristic dream, and all design calculations were done by the design teams using standard mathematical formulae, pen, paper and active brain power. A high level of secrecy was essential, which mitigated against open communication of new ideas. There was no Dick Smith or Tandy available to pick up complete units to replace and repair a fault. An Avometer, soldering iron, a few spare "tubes" and lots of trial and error were the standard tool kit for the maintenance mechanics. In combat zones under darkened ship conditions, it was common for operational and maintenance work to be done in restricted light in a confined cabin with ambient temperatures 40 degrees Celsius plus, and the unfortunate personnel occasionally retching a previous meal into a bucket as the ship rolled and pitched in heavy seas. Circuit diagrams and maintenance manuals were shipped anything up to 6 months after the equipment had been commissioned. Yet despite all these barriers, the RAN had a powerful pantry of equipment and the innovative human skills to allow Radar's effective uses in many different circumstances. The articles which follow this introduction illustrate this.

For readers with little knowledge of Radar, the article “Radar Basics” will offer simple explanations about the concept of this technology, as well as provide explanations of some of the technical words and terms used in the articles.

The terms aerial and antenna are interchangeable. Where a distance is indicated in miles, this means Nautical Miles (NM). One NM is approximately equal to 2,000 yards or 1.883 Kilometres. The original terms cycles (cs) and megacycles (Mcs) have been changed in recent years to Hertz (Hz) and Megahertz (MHz) respectively.

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Early Days

By Cherub Log & Skip Distance

In 1935, the Royal Navy’s most advanced method of detecting distant objects such as enemy ships and aircraft was 7 power binoculars. Four years later at the outbreak of World War 2, the new technology variously known to the British as RDF, Radio Direction Finding, Range and Direction Finding, Radio Location, and to the USA as Radio Echo Equipment, was capable of detecting aircraft up to 60 nautical miles distant. Later the allied forces used the common terminology of Radio Detection and Ranging, which became abbreviated to RADAR.

Radar was not invented. It was a progressive development of concepts in the UK, the USA, Germany, Japan, France and Italy over a period of perhaps 30 years. These developments focused on the four main components of a Radar system, namely a radio transmitter with a pulse generator, an aerial array to send and to receive the electromagnetic pulses, a receiver to amplify and interpret the echo pulses, and an indicator such as a cathode ray oscilloscope to display the results for human interpretation.

In the early part of the 20th century, knowledge of developments in different countries was shared. A prime example is the Japanese developed Yagi directional aerial. However it became apparent that the knowledge being accumulated could be of vital security importance, and a veil of secrecy spread over the whole process in all of the technologically advanced countries from early 1930 onwards.

In February 1935 during British experiments, an aircraft was detected at a range of 8 miles as it was flying within the beam of the BBC’s 50 metre short wave station at Daventry. Recognizing the requirement to create high powered transmitters operating in the ultra shortwave spectrum, experimental work resulted in laboratory models which operated at 50 centimetres, and a magnetron valve capable of working at 36 centimetres. However, at this stage, these were a long way from being incorporated in operational equipment.

The RN required short wave equipment, because longer wave equipment meant longer and bigger aerial systems, which while suitable on land, were impractical in a ship. So the RN development focus was on equipment operating in the S, C and X bands that is wavelengths between 3 and 30 centimetres. However, as shorter wavelength equipment was still very much in the development stage, the RN had to be content with the Type 79 until 1940 with the introduction of the type 281, followed by the type 271 in 1941. During this intervening period, the Type 79 under went a number of modifications, improving its range, power output, and general capability.

The RN fundamental operational approach was that Radar should be used for early warning, and that the conventional range finding process of optical range finder would then be used to track and engage the target. To this end, the RN stated objective was to have Radar which would give early warning of aircraft at 60 miles and ships at 10 miles. Further that the Radar would provide precise location of aircraft at 10 miles and ships at 5 miles. However, with the rapid advances made in the technology, it wasn't long before Radar was used for a number of functions such as early warning of ships, early warning of aircraft, gun direction and control, navigation.

The first RN ships to be fitted with type 79 Radar were the battleship *Rodney* and the cruiser *Sheffield* in early 1938. *Sheffield* did trials and reported detecting aircraft 30 miles distant at 3,000 feet, 48 miles distant at 7,000 feet and 53 miles distant at 10,000 feet. By May 1939, improved transmitting valves improved these figures by an average of 33%.

It was about this time that Australia started to take an active interest in this new secret device.

Although the UK had an operational Radio Location system (aka RDF or Radio Direction Finding) in 1937, it wasn't until early 1939 that Australia took an active interest in this secret technology. Throughout all of 1939, there was much highly secret correspondence between such luminaries as Australia's High Commissioner to UK, Stanley Bruce, the two prime Ministers Joe Lyons (who died in 1939) and Robert G. Menzies, Australian cabinet ministers, senior officers of Australia's armed forces,

and members of Australia's Radiophysics Board. A key person in this latter organisation was Dr. D.F.Martyn, D.Sc., Ph.D., A.R.C.Sc., F.R. Met.S., F.Inst. P., who was sent to UK to investigate and to
report. In March 1939 Dr. Martyn sent a telegram to the PM Joe Lyons recommending that some of this RDF equipment should be purchased. The PM immediately authorised an order to be placed. One of the first recipients of the equipment was H.M.S. *Amphion*, destined to become H.M.A.S. *Perth*.

Following Dr Martyn's UK visit, a top level Australian government committee was formed to evaluate aspects of this new technology, Radio Location. The committee decided that a Radiophysics Laboratory should be established in the grounds of the University of Sydney. A further decision was that Australia should develop equipment as an alternative to relying on UK production and availability. These recommendations were fully supported by the Australian government, and steps were taken to implement the establishment of the required procedures. In broad terms, the Radiophysics Laboratory became responsible for the design and development of prototype equipment, for the training of senior personnel of the armed services and their respective support functions, and in providing training in the various scientific aspects of the operation of the equipment. The Post Master General's Department became responsible for advising the Radiophysics Board on the types of equipment required, and for the installation, operation and maintenance of the equipment.

The laws of supply and demand being no different for Radio Location than for any other commodity, coupled with Britain's preoccupation with the war in Europe meant that availability of equipment for the Australian armed forces was extremely limited. Thus the need for self sufficiency. To this end contracts were let to Amalgamated Wireless Australia (AWA), and to STC (Australia) for the manufacture of units of Radio Location models, which soon became known as Radio Detection and Ranging, which in turn became truncated to RADAR.

For the RAN, one of the first sets produced was the A272 which did sea trails in HMAS *Kybra* in November 1942. In May 1944, an upgraded version of the A272, the A276, did sea trials in HMAS *Yandra*. (See separate article by PORM "Jake" Kerr on A272/A276 comparison)

Pre war *Yandra* and *Kybra* were small coastal steamers. Both were requisitioned by the RAN, fitted with a 4 inch gun, depth charge equipment aft and port & starboard antiaircraft guns. Their prime role however was as training vessels for Radar operators, and for this they were equipped with type A286 forrard and aft, A272 forrard and aft, and 271 aft. The 271 was replaced by type A276. As well an A79 was fitted for the purpose of providing performance assessment for "Bailey Boys". (See separate article on Bailey Boys)

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A Radar Officer

(The following is an extract of a letter written 19 September 1995 by David Medley to John Saywell OAM)

By Lt (Sp) David John Medley

I was the first officer recruited directly into the RANVR for RDF duties on 1 November 1941 . This was in response to an ad which appeared in the Melbourne papers around September 1941. At that time I was the only one recruited and I suppose probably the only applicant at that time. I was transferred to the Admiral's staff in Sydney where I was assigned to the Flag Lieutenant, Lt Commander John Bath. Also on this staff was a Warrant Officer by the name of Jock Smart. Jock was a Telegraphist and had been assigned for RDF duties. He knew very little about RDF and was happy to have me aboard. Little did he know that I knew nothing about it either but I did have a Masters Degree in Physics, had been a ham radio operator for some years, and interested in electronics as far back as I could remember. This deficiency was soon rectified as I was given a crash course at the Radio Physics laboratory and access to all the classified material the RAN had at that time , which I absorbed like a sponge. After a sojourn at Flinders where I was supposed to learn how to be an officer, I was assigned to help with the RDF installations on "*Canberra*", presently refitting at Garden Island. On completion of this work early in 1942 I was assigned to her as RDF Officer. Subsequent events were recorded in "The Shame of Savo", so I will not repeat them here. (See Editor's note)

I have only the haziest recollection of the "Bailey Boys" as I never had anything to do with the training school at HMAS *Watson*. I do recall that after I returned from the Savo affair, four RAAF officers and four RAAF mechanics were loaned by the RAAF to assist in the training of RDF operators.

Also about this time (late 1942), a distinguished A/S officer, Lt Tom Cree DSO, returned from Europe and was assigned OIC of the RDF section in Navy Office Melbourne, and I essentially worked for him for the remainder of my stay in the Navy.

Even at this time I was the only officer with a firm technical background and I suppose I was regarded as something of a "Whiz Kid". In any event I was frequently called upon to work on installations which had been beyond the capabilities of the personal (sic) concerned. I remember working on the RDF installation on "*Queen Mary*" while she was in Sydney. I remember working all night on an obscure fault in a gunnery control Radar on "*Warramunga*", and I remember being sent to service RDF equipment on board a royal Dutch cruiser called "*Van Tromp*" in New Guinea. I remember vividly a spell in Brisbane with a

US Navy submarine tender which was installing gunnery control Radars on "*Australia"* and "*Hobart"*. I was the liaison between the RAN and USN and I can recall that this was a fun time, and I learned a lot more about Radar from a Westinghouse Field Engineer who was supervising these installations.

I remember being sent to the USN PT boat bases on Guadalcanal and Savo Island sometime in 1943 to learn as much as I could about the SO Radars which the RAN had purchased for installation in the Fairmiles. These were subsequently installed at *Rushcutter* and I would suppose I supervised at least the first several installations. My most vivid recollections of this period were an overnight stay with a bunch of Coast Watchers who were waiting to be picked up by a submarine and deposited behind enemy lines and a ride on a PT boat from Guadalcanal to Savo.

As to the laboratory, I was nominally in charge of it while it was at *Rushcutter* from the time I returned from "*Canberra*" until I left the Navy in late 1945. I say nominally because I was away on special assignments a great deal of the time. On the other hand Alan Young was there all the time and will remember a lot more detail than I. The functions of the lab were as far as I can recall:

1. To provide a test facility for acceptance testing of Radar equipment being built in Australia.

2. To maintain a set of accurately calibrated test instruments which could be used to maintain standards of accuracy at RAN service bases.

3. To test new Radar equipment from overseas and to become familiar with it before it was installed in ships.

4. To develop new ideas as appropriate. In this area I worked on a Doppler Radar idea which has just now become a hot topic here in the USA. I also worked on Radar jamming equipment in the latter part of the war.

In 1945 it was decided to transfer the lab to *Watson*, and Alan and I designed a building for it. Whether this was ever built I am not sure but I do know the lab was never transferred to Watson, but was reinstalled out at the Navy Stores facility at Leichhardt sometime in 1945 – 46.

Editor's Note. See "Shame of Savo", by Commodore Bruce Loxton, Chapter 8 "Preliminary Moves" pages 62 on, and Chapter 23 "The Verdict" pages 254 on.

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HMA Ships 1939 – 1955 Radar Equipped

Compiled by Cherub Log

Many HMA ships were fitted with Radar, but only the larger vessels have been included in the following list. Vessels such as the Fairmile B motor launches, and requisitioned ships such as Ping Wo, Poyang and Yunnan are not included.

Ship Name	Class of Vessel	Radar Sets
Adelaide	Cruiser (ITC)	271. A290. SC.
Anzac	Destroyer (B)	275. 293.
Arunta	Destroyer (T)	285. A286. 293. 974. SC. SG.
Australia	Cruiser (C)	A286. 960. 273. 281. 282. 284. 285.

Barcoo	Frigate (R)	A276. 285. A286
Barwon	Frigate (R)	A276. 285. A286.
Bataan	Destroyer (T)	285. A286. 293. 974. SC. SG.
Bathurst *	AMS (Corvette)	A272. A276. A286
Bungaree	Aux Minelayer	NK
Burdekin	Frigate (R)	276. 285. 286
Canberra	Cruiser (C)	271. 273. 281. 282. 284. 285. A290.
Condamine	Frigate (MR)	A276. 285. A286
Culgoa	Frigate (MR)	A276. 285. A286
Diamantina	Frigate (R)	A276. 285. A286
Gascoyne	Frigate (R)	A276. 285. A286
Hawkesbury	Frigate (R)	A276. 285. A286
Hobart	Cruiser (ML)	A276. 277Q. 281AEW. 282, 285, SG.
Kanimbla ‡	AMCruiser	273. A290.
Kybra	Patrol	79. 271. A272. A286
Lae	LST	NK
Labuan	LST	NK
Lachlan	Frigate (R)	A276. 285. A286
Macquarie	Frigate (R)	A276. 285. A286
Manoora ‡	AMCruiser	A290. 273
Moresby	Survey & Escort	NK
Murchison	Frigate (MR)	A276. 285. A286
Napier	Destroyer (N)	271. A286. 291. SG. 285
Nepal	Destroyer (N)	271. A286. 291. SG. 285
Nestor	Destroyer (N)	271. A286. 291. SG. 285
Nizam	Destroyer (N)	271. A286. 291. SG. 285
Norman	Destroyer (N)	271. A286. 291. SG. 285
Parramatta	Sloop (IG)	A272
Perth	Cruiser (ML)	A286. 273. 281. 284. 285.
Quadrant	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quality	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Queenborough	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quiberon	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Quickmatch	Destroyer (Q)	262. 277. 285. A286. A290. 293. 974.
Shoalhaven	Frigate (MR)	A276. 285. A286
Shropshire	Cruiser (C)	273. 277Q. 281. 282. 283. 284. 285. SG.
Stuart	Destroyer (S)	A290.
Swan	Sloop (G)	272
Sydney	Aircraft carrier	277. 293. 960. 984
Sydney	Cruiser (ML)	262
Tarakan	LST	NK
Tobruk	Destroyer (B)	275. 293
Vampire	Destroyer (V&W)	A290.
Vendetta	Destroyer (V&W)	286. A290.
Vengeance	Aircraft carrier.	NK
Voyager	Destroyer (V&W)	A290.
Warramunga	Destroyer (T)	285. A286. 293. 974. SC. SG.
Warrego	Sloop (IG)	A272.
Waterhen	Destroyer (V&W)	NK
Westralia ‡	AMCruiser	273. A290.
Yandra	Patrol	79. 271. A272. A286
Yarra	Sloop	NK

* 56 Australian built Australian Minesweepers (Corvettes)
‡ Converted to Infantry Landing Ship (ILS) 1943.

B. Battle class
C. County class

G. Grimsby class
IG. Improved Grimsby class
ITC. Improved Town class
ML. Modified Leander class
MR. Modified River class
N. N class
Q. Q class
R. River class
S. Scott class
T. Tribal class
V&W. V&W Class

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Radar Types

By Cherub Log & “Skip” Distance

Of the many Radar types developed by the UK, USA and Australia, 23 were considered for use in R.A.N. vessels. With three exceptions, all were ascribed a 3 digit identification number, e.g. 277. One exception was the early UK developed 79. The other two were the US “Sugar George” SG, and “Sugar Charlie” SC. A prefix of “A” meant Australian designed and built. Suffixes of “M”, “P” & “Q” meant 1st, 2nd and 3rd modification respectively. Suffixes of “X”, “Y” & “Z” meant 1st, 2nd and 3rd experimental set respectively. Suffix “U” meant modification for fitting to small craft e.g. MTBs.

During her commissioned life, a ship might have had installed as many as 8 or 9 different and modified Radar types, yet carry only 3, 4 or 5 at any one time.

Admiralty classifications and examples of Radar types were as follows:

WS	Warning of surface ships. 271 272 273
WSR	Warning of surface ships and accurate ranges. 271M 272M 273M
WA	Warning of aircraft. 79
WAR	Warning of aircraft and accurate ranges. 279 280 281
WC	Warning of surface ships and aircraft close. 286 291
WCR	As WC, also accurate ranges. 290
GS	Gunnery surface low angle. 274 284
GA	Gunnery aircraft high angle. 275 285
GC	Gunnery close range. 282 283 289

The symbol § indicates that the data were not available when this article went to print. Some of the performance figures are close approximations

ID Number: 79. Manufactured in: UK. In service August 1938. Primary Function: Long range air warning. Operating Frequency: 42.827 MHz, 7 M, VHF band. Antenna: §. Output: 70 Kw. PRF: 50 Hz. Pulse: 10µseconds. Beam: §, Range: 60 NM. Display: §. Power Supplies: §.

ID Number: 262. Manufactured in: UK. March 1945. Primary Function: Gunnery close range. Anti aircraft. Operating Frequency: 10,000 MHz, 3 cm, S band. Type of Antenna: Rotating disc, 1 ½ degrees off centre, conical scanning waveguide fed, fitted to STAAG and CRBFD mounts. Output: 30 Kw. PRF: 150. Pulse: 0.5 µsecond. Beam: horiz 5.2º, vert5.2º. Range: §. Display: §

ID Number: 271. Manufactured in: UK. In service: May 1941. Primary Function: Surface warning

Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Dual flat cheese half elliptical. Magnetron antenna mounted. 370 degree rotation only. Housed in a plastic lantern. Output: 90 Kw. PRF: **§**. Pulse: **§.** Beam: horiz 5º, vert 20º. Range: 25 NM. Display: Initially A scan, prior to PPI development. Power supplies: §. Type of Display: Initially "A" scan (prior to PPI development)

ID Number: A272. Manufactured in: Australia by AWA. In service January 1941. Primary Function: Surface warning of submarines and small craft. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Dipole in parabolic reflector. 370º rotation hand driven by "M" type transmission. Galvanised iron waveguide. Housed in timber lantern. First Australian magnetron fitted set. Output: 10 Kw. PRF: 50. Pulse: §. Beam: §. Range: 25 NM. Display: "A" scope in Radar office. Power supplies: 230volt 50 cycles.

ID Number: 273. Manufactured in: UK. In service: January 1941. Primary Function: surface warning
Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Double cheese. Receiver above, transmitter below. Gyro stabilised. Magnetron mounted on the antenna. Output: 70 Kw. PRF: §. Pulse: §. Beam: §. Range: 25 NM. Display: "A" Scope. Power Supplies: §.

ID Number: 275. Manufactured in: UK. In service: January 1945. Primary function: Gunnery control high and low angle. Operating frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Two nacelles, transmitter starboard side, receiver port side. Output: 400 Kw. PRF: 600. Pulse: 0.5 µsecond. Beam: horiz 4.8º, vert 5.2º. Range: §. Display: §. Power supplies: 180 volts 500 cycles. (Was part of the Flyplane Predictor System).

ID Number: A276. Manufactured in: Australia. In service: January 1944. Primary Function: Surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Type of Antenna: Parabolic small single dish, continuous rotation, stabilised in azimuth.. 10 RPM in either direction. 80 degree sector sweep. Output: 500 Kw. PRF: 500. Pulse: §. Beam: horiz 3.5º, vert §. Range: 16 NM. Display: PPI. Power supplies: 180 volts 500 cycles.

ID Number: 277P. Manufactured in: UK. In service: September 1943. Primary function: Surface and air warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Type of antenna: AUK was approx 1.35 metres in diameter circular dish being waveguide fed rotating at 18 rpm. The Antenna could be elevated for aircraft slant height ranging. Power output: 400 Kw. PRF 500. 1.9 µsecond pulse. Beam horiz 4.5º, vert 4.5º Range 35 NM. Display: HPI design B. Power supplies: 180 volts 500 cycles.

ID Number: 277Q. Manufactured in: UK. In service: January 1944. Primary function: Surface and air warning. Operating frequency: 3000 MHz, 10 cm, S band. Type of antenna: ANU parabolic reflector rotating at 18rpm. The antenna could be elevated for aircraft slant height ranging. Power output 500 Kw. PRF 500. 1.9 µsecond pulse. Beam horiz 4.5º, vert 2.5º. Display:HPI design B. Power supplies:180 V 500 cycle..

ID Number: 281. Manufactured in: UK. In service: December 1940. Primary function: Air search. Operating frequency: 90 Mcs, 3,3 metres, VHF. Antenna: Separate dipoles for receiving and transmitting. Transmitting antenna mounted on mainmast and fed by twin wires with spreaders of plastic at approx 70 cm intervals. Receiving antenna mounted on foremast and fed by pyrotenax Coaxial fed. 5 rpm. Output: 600 Kw. PRF: § Pulse: §. Beam: horiz 40º, vert §. Range: Up to 100 NM. Display: "A" scope. Power supplies:

ID Number: 282. Manufactured in: UK. In service: §. Primary function: Gunnery control. Operating frequency: 180 Mcs, 1.67 metres, VHF band. Antenna: Yagi attached to the Director and controlled by the Director. Output: 15Kw, output valve was micropup. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: 180 volts 50 cycles.

ID Number 283: Manufactured in UK. In service September 1942. Primary function AA Fire Control. Operating frequency: 180 Mcs, 1.67 metres. VHF band. Antenna §. Output: 15 Kw. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: §

ID Number: 284: Manufactured in: UK. In service: December 1940. Primary function: AA Fire Control. Operating frequency: 599,584 Mcs, 0.5 cm L band. Antenna: § on top of director. Output: 25
Kw. PRF: § .Pulse: §. Beam: §. Range: 10 NM. Display: §. Power supplies: §.

ID Number: 285: Manufactured in UK. In service January 1941. Primary function: AA Fire Control. Operating frequency: 180 Mcs, 1.67 metres. VHF band. Antenna §. Output: 15 Kw. PRF: §. Pulse: 15 µsecs. Beam: horiz 20º. Range: §. Display: §. Power supplies: §.

ID Number: A286P. Manufactured in: Australia. In service: January 1941. Primary function: Surface and air warning. Night warning of surface craft up to 6 nautical miles. Would detect aircraft up to 86 NM depending upon aircraft altitude. Operating Frequency: 176 MHz, 1.7 metres, VHF band. Antenna: 286M fixed Yagi later replaced by 286P rotating bedstead array having horizontal dipoles.
Rotation caused by hand operated Bowden cable for 370º rotation, later replaced by “M” type system.
Output: 100 Kw via coax to antenna. PRF: 1000. Pulse: 2 µseconds. Beam: §. Range: §. Display: “A” scope in Radar office. Power supplies: 80 volts 1000 cycles.

ID Number: A290. Manufactured in: Australia. In service: 1941. Primary Function: Air search. Operating Frequency: 200 MHz, 1.5 metres, VHF band. Antenna: Yagi with 4 directors and 3 reflectors. Output: 100 Kw. PRF: §. Pulse: 0.5 µsecond. Beam: §. Range: §. Display: §. Power supplies: §.

ID Number: 293. Manufactured in: UK. In service: January 1944. Primary Function: Combined air and surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Copper waveguide horn fed parabolic reflector, controlled by “M” transmission. Output: 500 Kw. PRF: 500. Pulse: 0.4 µseconds. Beam: horiz 2.5º, vert §. Range: §. Display: §. Power supplies: 180 volts 500 cycles
ID number: 960. Manufactured in: UK. In service: 1946. Primary function: Surface & air warning. Frequency: 88.175Mcs, 3.4 metres, VHF band. Antenna: Horizontal dipoles in grid array coaxial fed, continuous rotation 15 rpm. Output: 400 Kw. PRF: 250. Beam: horiz 35º, vert §. Range: §. Display: §. Power supplies: (see below).

ID Number: 974. Manufactured in: UK. In service: §. Primary Function: Navigation - high definition surface warning. Operating Frequency: 10,000 MHz, 3 cm, X band. Antenna: Dual cheese parabolic waveguide fed continuous rotation. Output: §. PRF: §. Pulse §. Beam: §. Range: §. Display: §. Power supplies:

ID number: 984. Manufactured in: UK. In service: §. Primary Function: Combined air and surface warning. Operating Frequency: 10,000 MHz, 3 cm, X

band. Antenna: Dual cheese waveguide fed. Output: §. PRF: §. Pulse: §. Beam: §. Range: §. Display: §. Power supplies: §.

ID Number: SC4, Sugar Charlie. Manufactured in: USA. In service: July 1943. Primary Function: Air warning. Operating Frequency: 9338 Mcs, 3.2 cm, X band. Antenna: §. Output: 7 Kw. PRF: 1000. Pulse: §. Beam: horiz 1.6º, vert 23º. Range: 25 NM. Display: §. Power supplies: §.

ID Number: SG. Sugar George. Manufactured in: USA. In service: February 1942. Primary Function: Surface warning. Operating Frequency: 3,000 MHz, 10 cm, S band. Antenna: Semi elliptical parabolic single antenna waveguide fed. Motorised rotation. Stabilised in azimuth 24 rpm. Output: §. PRF: §. Pulse: 2µseconds. Beam: horiz §, vert §. Range: §. Display: PPI

ID Number 960: (Notes provided by Ch. RE Gordon Wood). This long range warning set had better performance than 281. The display and control system was easy to operate. 960 had a range of 200 NM. It was fitted in cruisers and was associated with 277 & 293 for an integrated air warning system. Power supplies were common for these 3 sets and associated IFF. There was a master trigger for all transmissions. There were 3 versions of 960 each with a different antenna system. 960 with AQQ antenna had separate arrays for spot frequencies of 86, 88 and 90 Mcs. 960M had antenna system ANA, which was a light weight antenna and operated between 80 and 90 Mcs. 960P had antenna system ANB operating at 80 to 90 Mcs. It was installed on aircraft carriers and had a large screen for data presentation. Frequency variation in the various models of 960 was achieved via a manually operated selsyn.

The main power came from a special alternator comprising one 250 and two 500 cps machines synchronized mechanically simply by being driven on one shaft. The 250 cps machine provided power to the 960 modulator. One of the 500 cps machines provided power to the other txs associated with 960, and the second 500 cps machine provided power to the receivers and displays. Power delivery of the alternator ranged between 6 and 18 KVA.

The modulator gave 5 & 15 µsecond pulses at a PRF of 250. Peak power output was between 400 and 450 Kw. The 960 took 30 minutes to warm up, and 1 ½ minutes to switch on. Cathode followers allowed up to 8 PPIs and 3 sector displays to be connected.

Ranging Units RTB & RTE. While not Radar sets , these units were used in conjunction with the PPI and TPI displays to provide accurate ranging for both long and close range armaments. The 3 ranges were 0 to 10,000 yards, 0 to 36,000 yards and 0 to 100,000 yards.

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GCI Radar

Introduction by Cherub Log

GCI Radar was a very early ground installation, coming into service in the UK possibly 1937. GCI stood for Ground Control Interception, and as such was used by the RAF for vectoring in British fighter aircraft to approaching German attack aircraft. When the RAN established its Fleet Air Arm base at HMAS Albatross in the late 1940s, a Type GCI was installed near the intersection of the runways 21 and 26. It is believed that the system had a dual role of GCI and GCA, Ground Control Approach. This was one of five navigational aids to aircraft control at HMAS Albatross. The others, mentioned in other articles in this collection were the Type 277 Q 10 cm radar installed on nearby Nowra Hill, the FV5 VHF

Direction finding equipment installed 1 Km south of the control tower, the AH6 HF DF installed 1 Km north of the control tower and the YG beacon, installed on Nowra Hill. Thus the risk of losing an aircraft during night flying exercises was quite low.

GCI by E.C. “Ted” Strauss

As an “on loan Pom” in the early to mid fifties, I spent some time as the LREM at the GCI site at RANAS Nowra, and really enjoyed the experience being the only Radio Mech on site. Lt Cdr Brasch was the Air Direction Officer at the time. Today he would be called SATCO. He appeared to have more faith in the GCI than he did in the more modern 277 installation on Nowra Hill. All three of us, Brasch, me and GCI, got along well together.

The GCI was an early Radar , made in about 1935 or 1936, with a rotating aerial and operating in the 200 Mcs band. Display was a PPI showing range and bearing, and an “A” display from which target height would be calculated. Power output was in the region of 100Kw peak, and the PRF would lie between 150 and 350 PPS. The antennas a wooden frame mounted on a wooden hut, all of which rotated. The frame was covered in chicken wire and mounted two horizontal rows of dipoles which were switched in such a manner as to result in three transmitted lobes, thus giving height cover from 4 to 30 degrees above horizontal. The aerial was fed by an open pair. In the Nowra installation, the range and bearing information was transmitted via a locally designed transmitter feeding a Yagi array to remote displays in the control tower.

The original system was an on-site console housing some of the electronics, and the PPI and “A” scan displays for the operator’s use. Target height calculation was by means of a chart with range and decimal fraction axes. From the “A” display the operator assessed the fraction of a second echo of a target with respect to the primary echo, and used this fraction and the range to read the altitude off the chart. I had the experience of operating the height plot on an occasion when due to sickness there was a shortage of Radar Plotters coupled with an important exercise. For the age of the system, the height plotting was remarkably accurate.

Cherub Log’s note:

“Ted” Strauss has provided good quality photocopies of the major circuits which together made up the Type GCI. These circuit diagrams, dated September 1947, are as follows:

Control Unit 181. GCI Multivibrator unit. Intensifier unit. Monitor unit. Transmitter unit. Switch unit type 38. Calibrator and phase splitter. Modulator unit.RF unit. Amplifier type A3175. IF unit. Aerial rotating gear. Turning gear Bloc diagram.

Some of the thermionic valve types used are as follows:

IF Amplifier, VR 91pentodes. “A” scan monitor VCR112. Modulator SP41 pentodes and VT127 tetrodes. Calibrator and phase splitter KTZ41 tetrodes. Multivibrator unit VR91 pentodes. RF preamplifier RL7 pentodes. HT DC supplier from two V1901 rectifiers. Transmitter two VT 98A triodes

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A272, A276 Comparison

By “Jake” Kerr. PO RM

As I recall the A276 antenna control, it had a 3 position switch which allowed “Continuous”, “Manual” or “Sector” mode of operation. “Continuous” gave a turning rate of up to 10 rpm in either direction via a Centre Zero Pot. “Manual” gave control to a small crank handle, i.e. the antenna would auto-follow in either direction as fast as the handle could be turned. “Sector” allowed the antenna to be positioned manually on a desired bearing, and a Sector Pot controlled the angle of the swept sector about this bearing, i.e. 5- 10 – 20 – 30 – 40 degrees of sector. The antenna table for the A276 was stabilised in azimuth, i.e. the PPI coil drive was stabilised

The A272 was a completely different kettle of fish from the A276. The antenna was modeled on the English 270, and consisted of two cheeses mounted one above the other. The lower transmitted, the upper received. The cheeses were about 4 or 5 feet across the horns, and the whole antenna stood about five feet high. It was contained in a plywood lantern, approximately 8 feet in diameter and 5 ½ feet high. The antenna was mounted atop the 20 inch Searchlight platform. Access to the antenna itself was via a removable plate in the lantern base.

The antenna was motorised using the same system as the BAP/H/M (for A286Q) i.e. the AS1 and AS 3 ASDIC controllers. Rotation was limited to 360 degrees, with a 5 degree overshoot each side of dead astern via a pair of traveling limit switches. It was stabilised in azimuth.

A 10 centimetre pipe from the transmitter terminated just inside the base of the lantern. Here it was matched to a 75 Ohm cable which went once around the antenna base (to allow for rotation) before terminating on fixed plumbing at the back of the cheese. The fixed plumbing went through the base of the cheese to within 6 inches of its front, where it ended in a 20 cm dipole (tuneable). The RF from the dipole was reflected by a plate across the front of the cheese, and came roaring out of the cheese in a solid beam. The Rx system was identical with a separate 10 cm pipe at the back of the receiver. (No TR switch – how primitive!).

Like the A276, the A272 was a spark gap modulated job. But here the similarity ends. The Tx/Mod unit was contained in a standard AWA crackle finish box about 3 feet wide, 1 and ½ feet deep, and 4 feet high. The top 1 foot section was the Tx, and the rest was the modulator. (For Tx maintenance it was necessary to lift the Tx clear of the Mod locating studs, and remove the front of the unit. Considering the weight of the old magnetron permanent magnets units, it can be understood why Corvette Radio Mechanics had weak wills and strong backs). To make matters worse, the unit was positioned just outside the door of the Skipper’s cabin, and under the bridge ladder. In an attempt to protect it from sea water, a metal cabinet had been added, which further restricted access. However the cabinet did screen out some of the Tx noise.

Inside the grey crackle box, the modulator was a fairly conventional thing. A couple of front panel switches, a form of Variac, power transformers, C-1, a resonant line, and a rotary spark gap. The Tx, in the upper tray, consisted of a magnetron and associated pieces, plus an odd piece of tunable plumbing which matched the output of the magnetron to the 75 Ohm cable and the 10 cm antenna feed pipe. The spark gap was another odd thing. It was like the double ended rotary spark in the A286Q, except that the stator of the motor could be moved manually to correct the phase of the spark. (one could tune for maximum smoke!)

The other difference was in the spark gap itself. The fixed set-up here was a point on one side, and a ball on the other. The rotating bit consisted of a ball on one side and a gramophone needle on the other.

So the spark jumped from a fixed point to a rotating ball, then from a very fine moving point to a fixed ball. The needle points were replaceable, and as a Naval Stores item, their progression was from Naval Stores for service in the SRE gramophone, and then to the A272.

The Radar office did not change much when the A276 replaced the A272. In the 20th Minesweeping flotilla the A276Q was on the right as the door was opened, with the 2 A272 racks next in line. All 3 racks faced forward. This compartment was formerly the Skipper's bathroom, and under the racks, the four feet of the removed bath could be seen clearly. This compartment measured 5 feet by 5 feet by 8 feet high. When facing the 2 A272 racks, the one on the left was 4 feet high, the top 12 inches of which sloped slightly backwards. This was where the A scan was mounted (a complete A276 A scan). Immediately below this was the AS3 antenna control, with the AS1 Relay Panel in the next drawer down. The rack on the right was full height. The receiver waveguide terminated on the deckhead immediately above this one, with a 75 Ohm cable finding its way down to the front of the receiver about 12 to 18 inches below. The first panel down was the Radio Mechanic's hideaway. It contained ALL of the test equipment (a model 7 Avometer), both equipment manuals, and a carton of Craven A.

Next was the receiver, which was a prototype of the one in the A276. Then there were the trays containing the cumbersome power supplies.

The switches and regulators etc for starting the Rotary Power Supplies were all located on the forward screen of the office. The A4 motor alternator for the A286Q was located about 4 feet off the deck in the Barbette for the 4 inch gun (on the sailors' mess deck). The forward "donk" for the W/T office was immediately below it. The A7 motor alternator for the A272 was mounted at deck level outside the Coxswain's office/cabin. It served 3 purposes in life. One was to supply the Radar, another was to supply the clippers of the Chief Stoker's Hairdressing Firm, and the third was to keep the Cox'n awake at night

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Identification Friend or Foe (IFF)

A paragraph in the article Ancillary Devices will provide a general description of IFF. This information in this article which has been provided by Ch RE Gordon Wood provides some details of some of the specific units

<u>242 Interrogator (With 293Q Radar)</u>

The Mk 3 IFF system comprised a transponder which swept 3 small frequency bands allocated to Identification Operations. The transponder was actuated by an interrogator signal emanating from a low power transmitter receiver associated with the main radar set. Radar and interrogator transmissions were simultaneous, thus the response and echo returned together. The operating frequency was capable of being changed quickly and easily because of enemy jamming.

The transmitter design allowed high (10 Kw) or low (2Kw) power output. The frequency could be varied in a band of about 30 Mcs between 157 and 187 Mcs.

The transmitter and preamplifier contained an oscillator, series modulator and built in power unit, a preamplifier for the responsor, a gas gap TR switch for connecting the TX and responsor preamplifier to the common aerial and artificial load for measuring Tx output. The series modulator received its initiating pulse from the radar transmitter pulse, delayed by 3 µseconds. This caused the oscillator to transmit.

The essential link between the radar set and the interrogator was the modulator and mixer unit whereby the interrogator Tx pulse was synchronised as a sub multiple of the radar pulse rate.

The responsor was a superhetrodyne receiver having 1 RF stage, local oscillator, diode mixer, 5 IF stages, diode detector and video amplifier.

The aerial array was a chandelier type with dipoles and reflector assemblies. These comprised two dipoles connected in parallel and mounted half a wavelength apart. Each dipole had a single reflector fixed approximately 1/5th of a wavelength behind the dipole. The aerial was fed by unbalanced pyrotenax cable.

242P Interrogator (With 277Q Radar)

Intended to be displayed on a UDU (Outfit JM) principally. This was similar to Outfit JH in that radar signals were sector selected and presented on upper trace, while IFF signals were continually shown on the lower trace, except during signal selection. The interrogator aerial turned with the radar aerial. As with the UDU, the IFF signals were being compared with faint after glow of a short bright trace. High brilliancy was not required and the repetition rate could be low.

251M

This was a beacon fitted in surface craft which may have been required to work with ASV fitted aircraft. When installed ashore it was known as 251M/S, and was used as a means of indicating the section of shore under consideration to an aircraft fitted with interrogator at the right frequency. It had 3 functions:

1. It enabled ASV fitted aircraft to determine the range of the beacon.
2. It operated a warning light which indicated that a signal was being received. In aircraft carriers the light was fitted in the ADR.

3. It enabled messages to be sent to the ASV apparatus or interrogator by substituting a handkey for the automatic coding device.

The components were Power supply, Control panel and auto voltage control gear, Distributing board and rectifier unit, Transmitter 7AB, Receiver P27 or P27A, Aerial feeder system, Remote indicator unit. Under favourable conditions, a range of 70 miles could be obtained with aircraft flying at 2,000 feet. With ASV/X (Lucero), the range was reduced to 55 miles.

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Ancillary Devices

By Cherub Log and “Skip” Distance

In keeping with the focus of the articles in this collection, what follows here is a brief introduction to those electronic devices which were developed and used in conjunction with Radar. These were:

1. IFF. Identification Friend and Foe
2. DF. Direction Finding, MF, HF and VHF
3. Loran. Long Range Radio Navigation.
4. Radio Beacon
5. Radio Altimeter

6. Radio Compass
7. Typex encryption machine
8. Sonobuoy

1. IFF. Identification Friend and Foe.

This system was developed as ship borne and airborne equipment. Both operated on the same principle which was an automatic signal being transmitted from an interrogator to a target (ship or aircraft). If the target was fitted with a corresponding transponder, an automatic signal would be sent back to the receiver unit of the transmitting interrogator, and displayed on the Radar screen. In this case the target would be deemed “Friend”. Should there be no response from the target for any one of a number of possible causes, it would be deemed “Foe”. Security was provided by coding which could be manually incorporated into the units of the system. Thus if the enemy had access to the system units, he would also have to know the code settings for the day or time of operation in order to make effective use of the equipment.

The operational sequence for a ‘Friend’ was firstly a signal would be transmitted by the Interrogator’s transmitter. This would be received in the receiver unit of the Friendly Transponder which in turn would respond automatically by transmitting a response. The response would be received by the Interrogator’s receiver unit, called a Responsor, and a coded signal would be displayed on the associated Radar’s PPI or other display unit.

The ship borne interrogators were 242, 243, 941, 944. The ship borne transponders were 253, 954. The airborne AN-APX1, carried by all R.A.N. aircraft was a transponder only. The AN-APX 2, carried by Fireflies Mks 5 & 6 only, was an interrogator and transponder. (See separate article by Ch RE Gordon Wood)

2. DF. Direction Finding.

This was a device developed to provide an aircraft with information about its bearing relative to its operations base, whether this was a ground station or aircraft carrier. Normal HF or VHF transmissions from the aircraft would be received by the base receiver, such as AH6 or FH4 for HF and FV5 for VHF, and the relative bearing of the aircraft to the base would be automatically displayed on a PPI screen. This information could then be relayed to the aircraft via the usual HF or VHF communication channel. There was also a little used MF version, the FM12.

3. LORAN. Long Range Radio Navigation.

This is a device developed to aid in ship navigation over long distances. Typically 3 transmitting stations in a group would operate on the same frequency. All transmitting stations would be fixed and of known latitude and longitude. One station in the group would be the Master and the others the Secondaries. The principle of operation was to create pulsed signals at precise time intervals, such that a receiver tuned to the group frequency could compute the time differential between the Master and the Secondary signals, and from this derive a rough fix on the latitude and longitude of the receiving ship or aircraft. To provide world wide coverage, the fixed base Loran transmitters were high power and operated in the HF range at around 100 MHz.

LORAN could cover a vast geographical area, but its definition for close navigation was unsatisfactory. To address this need of a reliable navigational aid in confined waters where shipping traffic was heavy, such as the English Channel, the “Decca Navigator” was introduced. Unlike LORAN, the principle of

this system was that it used continuous transmission, and the phase differences of received signals from a number of relatively close shore based fixed sites were measured to establish the position of the receiving vessel. In the 21st century, Loran is still used extensively, in particular in the European community, as it is regarded as a safe alternative to other global positioning systems.

4. Radio Beacon.

This device was a VHF transmitter with a slowly rotating directional aerial. Within every twenty four 15 degree sectors of the compass, the transmitter would transmit a Morse code symbol twice. For example, in the sector north through 15 degrees east the Morse signal might be A (dit dah). Then in the next sector North 15 degrees east through N 30 degrees east the signal might be O (dah dah dah). And so on with a different Morse signal for all of the 24 compass sectors. Upon receiving these audio
signals, the aircraft crew would know in which general direction lay their base. The transmitters were YG beacon for land based and YE beacon for ship based transmitters. The aircraft installation was ZBX.

The advent of GPS has improved considerably the navigational assistance available to ships and aircraft.

5. Radio Altimeter (AYF)

This radio device operated on a principle different from that of Radar. The Radar principle is that the frequency of the signal is fixed and a comparison is made of the time of the transmitted signal with the different time of the returned signal. (See discussion on Doppler Effect in the article Radar Basics). In the radio altimeter, the transmission is frequency modulated, i.e. continually changing at a predetermined frequency. It is the frequency of the transmitted signal which is compared with the different frequency of the returned signal that is used to compute the aircraft's altitude. Note that this system is quite independent of atmospheric pressure which is the basis for regular altimeter construction. The transmitted frequency was frequency modulated at 120 cycles per second. At the higher range of 4,000 feet altitude, the operating frequency was 442 to 446 Mcs, and at the lower altitude range the operating frequency was 420 to 460 Mcs

6. The Typex Encryption Machine.

The Germans invented the "Enigma" machine in 1926. It wasn't until 1936 that the British decided to have their own machine cryptograph for enciphering all radio traffic. The Typex was based on the Enigma, but the early versions were quite inferior in design and operation when compared with Enigma. This was evident when the British troops were forced to evacuate Dunkirk, a number of Typex machines were left on the beach. Discovered by the Germans, the machines were simply destroyed as the Germans knew the Typex limitations. Various improved models were progressively developed, but it wasn't until the Mark VIII Typex was released that the British had a machine capable of receiving and transmitting Morse code signals and automatically causing plain text to be printed.

The Typex was an electromechanical device, with no electronic circuitry, simply direct current. It was essentially a standard typewriter keyboard connected to a teletype machine, but with infinitely variable internal electrical connections via a series of notched circular rotors. Each rotor had 26 double electrical contacts on both ends. Each contact on one end of a rotor was hard wired to a contact at the other end, but each rotor was wired differently from all others. Typically 25 rotors, each identified by a unique number, were supplied with a Typex device,

and typically 5 rotors would be fitted to the machine at any one time. One rotor was static and the others rotated. Each day, the rotor sequence would be changed, not by moving the rotors but by a plug board, similar to the very early manually operated telephone exchanges. Every Typex had to be changed identically and co-incidentally for the whole communication system to operate correctly. Thus via the transmitting and receiving Typex machines, encrypted electronic messages could be securely exchanged. Typex machines remained in use until the early 1970s.

7. Sonobuoy.

Early sonobuoys were non directional. Each cylindrical canister which contained the detecting and transmitting equipment was about 80 centimetres long and 12 centimetres in diameter. At the base of the cylinder was a hydrophone connected to the transmitter via an electrical cable 10 metres long. At the top of the cylinder was a whip aerial attached to the cylinder by a coil spring, and restrained against the cylinder by a quick release clip. Upon being dropped by the aircraft, impact with the water surface would cause three actions to occur. One would be to release the hydrophone which would descend in the water until stopped by the connecting cable. Secondly the aerial quick release clip would disengage, allowing the aerial to spring up and assume a vertical orientation. Thirdly the battery power to the amplifier and transmitter would be switched on, and the device would be in immediate operational mode. Operational frequency range was 62.9 to 71.7 Mcs. Effective range was a maximum of 3 miles. Battery duration was 4 hours.

Non directional sonobuoys were generally tuned to one of 6 different frequencies. As a pattern of sonobuoys was dropped, the observer would note the relative position of each one, such that when a target created audio noise was picked up by the hydrophones, the observer would know the approximate position of the target by tuning his receiver to the preset transmitter frequencies.

Later versions of sonobuoy had directional hydrophones, which meant that as few as 2 would need to be dropped in a pattern in order to get a fix on a target.

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H.M.A.S. Bataan

By Donald Crowley. HO PO RM

P. O. R. M. Don Crowley was drafted to HMAS Bataan early 1945 immediately prior to her being commissioned, and supervised the installation and testing of the US SG surface warning, and the US SC air warning Radars. This equipment was located in the Navigator’s chart room. As examples of the types of problems encountered in those early days, when it was imperative to “get the stuff in and sort out the problems later”, Don recalls the following incidents he encountered in Bataan

One was an interesting phenomenon which came to light in the early stages of comparing the ranges with those of the optical range finder in the gun director. In theory, the ranges should have been precisely the same, but they were different by a small amount. After examination of the data, it was reasoned that there was a perceptible time delay in the transit of the Radar transmitted signal from the transmitting magnetron to the antenna, and similarly of the returned signal from the antenna to the receiver. Once calculated and applied into the ranging

calibration, the factor remained constant until associated components were changed. The satisfying outcome was that there were no more arguments between the gun director and Radar plot crews as to which range was correct. This phenomenon was also noticed in the early days of television when because of the different cable lengths, the time taken for the video signal to travel from the various studios and outside broadcast units to the central operations room, the telecine, was different in every case. The TV solution was simply to delay the shorter path signals to equate to that of the longest path.

Pre commissioning trials are essential to ensure that as far as possible, all predictable problems have been resolved. Not quite so in Bataan's case where Full Astern had the desired effect on ship's speed, but the undesired effect of the generated heat melting the cables running up the mast, rendering all Radar instantly inoperative. So it was back to the dockyard for installation of protective heat shield on the mast cables.

Another problem was that the SC Radar did not perform well. Investigation revealed that the coaxial cables were below specification, and upon replacement showed a receiver signal gain of about 6db, quite significant.

Yet another was the difference in ranges of SG's PPI and the "A" scan displays. The PPI's extreme range was greater than that of the "A" scan, but this anomaly was not apparent until on one occasion the "A" scan operator was almost accused of being asleep because he did not detect an echo which had been detected and reported by the PPI operator. The alternative solutions were to either decrease the PPI maximum range to be coincident with that of the "A" scan, or to accept the fact of a design limitation. The later course was adopted, and henceforth when operating on maximum range, the PPI operator invariably would see a "blip" before the "A" scan operator did so.

Footnote: Jim Somervelle recalls that in 1947/48 Bataan had 2 US Radars. One was surface warning SG1 (Sugar George), and the other was SC4 (Sugar Charlie).

Don recalls that Shropshire had a potentially disastrous installation misadventure when fitting out in UK. Type 282 Radar was installed in the port and starboard small arms batteries, the pom poms. During an early workup exercise, aircraft simulating a port side attack were detected on the starboard system. Investigations revealed that the port antenna system had been connected to the starboard Radar and vice versa.

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HMA Ships *Canberra* 1 and ***Shropshire*** **Radar Equipment Fitted.**

By: Lieutenant Commander Mackenzie J. Gregory RAN Ret'd.

I served in HMAS *Canberra as* a Sub Lieutenant RAN from December 1941 until she was sunk at the Battle of Savo Island on the 9th. of August 1942. At the commencement of that Battle I was the Officer of the Watch on her bridge. *Canberra's* Radar Officer was David Medley.

About May of 1942, as part of a refit in Sydney, *Canberra,* was I believe, the first RAN ship to be fitted with Radar. She had the British Type 271 Radar set fitted, and Sub Lieutenant David Medley RANVR both fitted this set, and became the ship's Radar officer. I must say it was still considered a Black Art by senior officers.

Although we had picked up the US destroyer *Blue* on patrol on the seaward side of Savo Island at a distance of 30 miles previously, with misty weather on the night of August 8/9, we certainly did not detect by our Radar 271, the approaching Japanese surface force. But then neither did *Blue* or *Ralph Talbot* on picket duty, either see the Japanese visually, or pick them up on their Radar.

David Medley, post war went off to live m the United States and became a naturalised
US citizen, and still lives there. In 2004 we corresponded, and he had this to say about the Radar fitted in *Canberra.*

"I have never forgotten the short time I served on *Canberra* and have been haunted throughout the years about what I could or should have done to make the more senior officers aware of the
capabilities of the Radar equipment on board. 20/20 hindsight is always misleading and I constantly remind myself that in those days an RANVR Sub Lieutenant, wet behind the ears, was regarded as the lowest form of animal life, and not to be taken seriously. I doubt that Capt Getting even knew that I existed. He certainly never exhibited the slightest interest in the Radar installations.

I noted with interest that you served on *Shropshire*. I wonder sometimes why I was not given the opportunity to join *Shropshire* but I don't believe that subject ever arose. Although the court of inquiry absolved me from any blame I guess some stigma may have stuck to me. I was never sent to sea again except on short cruises involved with my work in developing new Radar for the navy which was what I was better fitted for anyway.

You and Bruce Loxton are the only members of the *Canberra* gunroom that I remember clearly. I suspect that this is because you were the only two people that were interested enough to ask about the Radar installations."

At the time, *Canberra's* Gunnery Officer was Lieutenant Commander D. M. Hole RAN, killed at the Battle of Savo Island 9/8/1942.

HMAS *Shropshire.*

I served in HMAS *Shropshire* as a Lieutenant RAN from December 1944 to mid 1946, she had a wonderful ship's company and was a happy and lucky ship. The fact that we did not lose a man to enemy action was, I believe, largely due to her Radar equipment fitted, and the great Radar operators who manned them. Our Task Force Admiral would signal to ships in company "Pay *attention to Porthole's Radar reports, SHE IS HOT STUFF! "*

Shropshire's Radar sets fitted were:

Type 281. Air warning. Frequency 90 Mcs. The transmitting antennas fitted on the mainmast and the transmitter was in the office at the base of the mast. The receiving antenna was fitted on the foremast, and its receiving office fitted on the flag deck at the foremast's base. The antennae rotated in synchronism.

Aircraft reports on planes went off to the Air Defence Office manned by Radar rates with Lieutenant Ron. Major in charge, here both enemy and friendly aircraft were plotted, and this office was in touch with ships in the Fleet by voice signal. The ship's famous call sign *"PORTHOLE"* was often on the air, and we were well known for the quality of our Radar warnings of enemy aircraft. In perfect weather conditions, Able Seaman Joe Barrington MID, who could read round the curved edge of the Radar screen could report the enemy as far away as 120 miles.

Type 273. Surface Warning. lOcm wavelength. 3,000 megacycles frequency. Antenna which was gyrostablised was in a lantern type structure on top of its office which in turn was located just forward of the after control. This set connected to an accurate range display panel in the transmitting station.

Type 274. Main Armament.

Antenna mounted on the main armament director located above the bridge, just forward of the foremast. Its office was below decks, and range and bearing for the main 8 inch gun armament was supplied to a display panel in the main transmitting station.

4 Type 283 sets. Auto Barrage Units.

There was one of these sets for each of the four 8 inch gun turrets, and each had a control station with a display unit on the upper deck. The main office for these units below decks. The objective of the 283 sets was to enable efficient use of the main armament against dive bombing attacks, and they proved useful against the Kamikazes. Each of these sets had a small fire control device like a mechanical computer. The main armament guns could be loaded with shells fitted with a time fuse, generally set for a different time in each gun barrel, the FC Device would work out the correct time, and fire the guns so that when the shell exploded, it was at the same place as the aircraft would be if it flew on at the same course and speed.

Type 285. 4 inch Antiaircraft Guns.

Antenna mounted on the Aft High Angle Control Director. The 285 office was below decks. Its function was to provide range and bearing for the 4 inch AA fire control.

Type 285. Multiple Pom Poms

One set to control each of the port and starboard Pom Pom mountings.

TYPE SG. Surface Warning. IOcm wavelength.

An American set, fitted after joining the 7th. Fleet. Antenna fitted on foremast with its PPI display in the Plotting Office below the bridge, used for both navigation and surface warning.

Type 277.Aircraft Tracking. IOcm wave length. This unit was fitted during a mid year refit in 1945. Antenna was fitted on the foremast, and its office was in a special extension built on the port side of the bridge structure. Its single dish antenna controlled for both bearing and elevation, and this equipment gave the exact location of its target.

As it turned out the war was almost over, we had the Borneo landings to come, and then the dropping of the two Atomic bombs hastened the end, Japan surrendered, and at last it was all over.

GUNNERY CONTROL.

The gunnery control Radar sets were combined in an integrated system, they all operated at the same frequency, about 600 megacycles. Power came from a large motor generator with a 500 cycle 180 volt output, to avoid interference there was a phase difference between the power supplied to each set.

Type 91 Jamming Transmitter

Radar Counter Measures were fitted in *Shropshire* and consisted of multi band receivers and a Type 91 jamming transmitter.

NOTES

I am beholden for the technical information to Lieutenant (P) R. Slayter RANVR, who supplied it to the Cruisers' Association.

During my time in her, *Shropshire's* Navigating Officer was Commander J. S. Mesley RAN, and her Gunnery Officer was Lieutenant Commander W. S. Bracegirdle DSC** RAN.

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HMAS Culgoa

By Desmond D. Miller. Commodore RAN Retired

My first ship was HMAS *Warrego*. Her only Radar set was a 272 . *Warrego* was in refit. It was Christmas leave period and I was in her for only 2 months.

From *Warrego* I went to *Culgoa*. She was fitted with 276, 286 and 285. The 276/286 office was at the foot of the mainmast, no doubt to enable the shortest straightest aerial feeder runs. The 276 PPI on the bridge was mounted vertically. To gain access to its innards one had to lift it clean off its metal case, and ideally the maintainer needed to be 7 feet tall, of powerful build, in order to avoid serious back damage. The magnetron was spark gap modulated, the moving part of the spark gap mechanism being fixed to the armature of a motor-generator. The spark gap was adjusted by moving the whole motor mounting frame – a fairly clumsy arrangement. In my experience, the 276 was a fairly reliable beast but apart from the Navigator, other bridge officers did not seem to be too interested.

The 286 was a poor performer, mainly because of the slow rotation of the antenna which was controlled by a modified Asdic controller. On the few occasions when we had formal exercises, the
"enemy" aircraft came in low and fast, and I don't recall ever detecting them. Aircraft at a distance and some height could be detected. It was also effective at detecting the tops of distant mountains around the coastline of Japan, much to the satisfaction of our Navigator.

Also fitted in the 276/286 office was a small bulkhead mounted IFF equipment – name unknown. There was no handbook for it, nobody ever asked me to switch it on, and I have no idea whether it worked or not. It had a round opening in the lower front panel labeled "Danger. Explosives". There was nothing in this tube. I assumed it was highly secret in wartime and was to be destroyed if the ship was in danger of falling into enemy hands.

The 285 Transmitter room was in a small space below deck roughly below the Director. There was just enough clear deck space in this compartment to accommodate a stretcher. I thus had a private sleeping space, a luxury certainly but a necessity also as there was not quite enough space in the PO's mess to sleep all the POs borne. The display equipment was in a small low space immediately below the Director. Fitted to the top of the Director were 6 Yagi (fishbone) aerials in a horizontal row with a curved metal concave reflector. Transmitter energy was produced by 2 valves, possibly NT99s, joined base to base and mounted vertically at the centre of a cylinder, height about 60 centimetres and diameter about 40 centimetres. It was highly polished and reflective inside - it may have been silver plated. Our instructor at *Watson* told us that you could cook and egg inside that cylinder, but he did not recommend that we try it, because "If you open the access panel and the safety interlocks do not work, it will fry your eyeballs". An early microwave oven?

I encountered an interesting problem with the 285. No matter what I did, the maximum ranges never reached the 'book' figures. I sought the advice of one of the Chiefs at the Port Radar workshop. He accompanied me to the ship and we climbed to the top of the Director. He took a quick look at the director dipoles of the 6 Yagi antennae, told me to undo the middle two, turn them upside down and retighten them. Engraved into the insulating block of the dipoles was its pattern number. He explained that they had to be all up or all down, otherwise the shape of the transmitted beam was distorted. Problem solved in about 5 minutes. *Culgoa* was then about 4 years old. I wonder how many of the 285 Yagis had been improperly installed, and perhaps never corrected.

Thinking back to that time in Culgoa, it seems to me that there was still a deal of scepticism about the reliability of Radar. The 286 was a poor performer as a detector of hostile aircraft. In the use of the 285 gunnery Radar, the few exercises we did were always in the day time and the Gunnery PO in the Director seemed always to produce ranges and bearings which satisfied the Warrant Gunner in the Transmitting Station below decks. As mentioned above only the Navigator seemed to be really interested in what Radar could do to assist him in his duties.

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HMAS Hobart

By Gerald E York. Lt Cdr RAN (Ret'd)

I served in HMAS *Hobart* for all of 1947 during her last trip with BCOF in Japan. This included a visit to Shanghai shortly before Chairman Mao arrived at the end of his "Long March". Other Radar mechanics on board with me were John (Bash) Harrell, ex PO Tel and Basil Richards. Kevin Duffy joined on our return from Japan in September. Lofty Waugh, ex PO RM was the Radar Officer and had just been commissioned as a WO (thin striper). Lofty joined the same time as I joined when he took over from Col Stewart. I left *Hobart* on decommissioning 12 December 1947 when Dick Withers and "Slim" Somervelle joined to complete the decommissioning phase and refit. On completion of the refit *Hobart* went into mothballs for several years before going to Japan for scrapping. In fact I was in HMAS *Melbourne* in Kobe when she arrived in Osaka to be scrapped. That was 1959 I think.

When *Hobart* was at sea, 2 RMs used to sleep in the 281 compartment, one in front of the Tx and the other inside the Tx next to the output bottles (See editor's note).

Hobart had the following Radars:

281 AEW. The transmitter was installed in its own hut on the upper deck midships between the main and foremasts. The antenna was mounted at the top of the mainmast. This was a number of stacked dipoles which gave a range of 200 plus nautical miles. The low frequency of 180 Mcs and antenna height gave it this excellent range.

277 combined surface and air warning. This had a parabolic reflector half way up the main mast. Its operating frequency was 3,000 Mcs, wavelength 10 cm. Its capability was aircraft detection (at height) 100 miles and large ships 50 miles.

SG (Sugar George). US design. Operated at 3,000 Mcs. Antenna mounted on top of the main mast just below the 293 antenna. PPI was mounted on the bridge. Navigation capability was up to 50 miles.

285. There were 3 of these for the 4" directors and 4" gun control. The Yagi antennas and transmitter were tuned to 450 Mcs. The “A” scan displays were mounted in the Directors.

282. There were 4 of these. For gun control of the Bofors and Oerlikons. They used Yagi antennas. The “A” scan displays were mounted in the Tx/Rx compartment on the main deck midships waist.

As well, *Hobart* had IFF and LORAN.

Editor’s note: All Radar transmitters delivered high power electromagnetic transmissions when operational, these transmissions coming from the Radar set’s power output valves, colloquially referred to as the bottles.

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HMAS Murchison

By George Holland HO PO RM

I commissioned HMAS *Hawkesbury* (River Class Frigate) in 1944 and served on her until mid 1946. I refer only to that experience.

We had an ex RN surface Radar E 271. Our aircraft warning set was an A 286.

The E271 was our sole gunnery range finder. The Axis had control of most of the world’s optical lens manufacturers so we were without an optical rangefinder. Calibration of the E271 was effected via a screwdriver potentiometer which broadened or narrowed the single green trace on a 6 inch CR tube. During navigation trials, and often at sea, the set could be calibrated using known range objects. During gunnery trials it became a subject of controversy between the gunnery officer and the Radar mechanic, the operators would observe the fall of shot on the screen and shout out the number of yards under or over the target the shot had fallen. The big problem with the E271 was that the impact of the forward gun firing would put the set off the air completely. The early germanium diode as the detector was the first cause but later we had mechanical problems with magnetrons and rectifiers. The magnetron was in a box directly underneath the dish, all contained within the housing above the Radar cabin. The whole assembly was rotated by hand over 365 degrees then wound back. The operator read the bearing from an engraved metal ring on the connecting shaft. This made it very hard to keep track of a vessel following astern. Power cables to the transmitter and coaxial cables from the receiver were constantly swept around and back. The early British 70 ohm coaxial cable was anything but flexible and several temporary repairs had to be executed at

sea in the cramped space of the Radar dome by cutting and re soldering the inner conductor and linking the outer braids with a section of a tobacco tin after carefully ironing the polythene dielectric with the hot soldering iron. The Americans only had 50 ohm cable but it worked and was more flexible so gradually I replaced all.

Then as we entered the tropics, the UK designed gear could not handle the moisture. Instead of half inch thick laminated bakelite insulation they had substituted two thicknesses of quarter inch and before long 10kv was arcing out of sight inside the panel. That took a lot of finding. I had to rig festoon carbon filament lamps inside the set to keep it dry.

For all of this we had Radar, we could monitor 70 ships in a convoy under blackout conditions. We could correct the fall of shot and maintain amazing accuracy of gunfire in surface combat. We could range on low surface reefs and land masses and we could locate a periscope at 2000 yards. Over a very short period of time the British had developed wave guide technology, the magnetron – albeit with some help from the Japanese hi permeability alloy Alnico, and microwave dish technology, all of which gave our side the advantage of working in the ultra high frequency spectrum.

Our aircraft warning Radar the A286 was a great achievement for Australian industry. All know of the rotating gramophone needles providing the transmitting pulse via the AV11 an all Australian valve designed and built by AWV the AWA valve company, the huge bedstead antenna built in the NSW Railway Workshops and set atop the mainmast. Those sets gave wonderful service.